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IMPERIAL BUREAU OF MYCOLOGY
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BY

DR. E. J. BUTLER, M.B., F.L.S.,
CRYPTOGAMIC BOTANIST TO THE GOVERNMENT OF INDIA.

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Dated the 27th February, 1903.

Previous references.

The first detailed reference to this disease appears in a Memorandum by Mr. McCarthy, Deputy Conservator of Forests in Coorg, on "The future supply and culture of Sandal in Coorg," in December 1899. Mr. Barber, Government Botanist, Madras, visited Coorg for the purpose of studying the disease shortly prior to my arrival. His report, however, was not available at the time, and I remained in ignorance of his work until my own was completed.

Area and period of affection.

2. The disease affects a portion of the Sandal area of Coorg and a smaller portion of Mysore. It would appear to be of recent origin, since it is hard to believe that so remarkable a disease could have escaped attention.

External characters of the disease.

3. The external characters of the disease are well described in the reports of Mr. McCarthy and Mr. Barber. There is, therefore, no need to dwell at any length on them here. A short account must, however, be given of its very peculiar symptoms in order to understand the course of the disease. From a certain moment all the new leaves produced, sometimes on a few isolated branches only, sometimes over half the tree, sometimes even over the

whole, take on new characters, becoming narrow, pointed, stiff and crowded together. From this moment the affected shoot never ceases its growth, differing markedly from the normal tree which lies dormant for a considerable period each year. The newly formed internodes are considerably shortened. As growth continues each new leaf is smaller, narrower, and more pointed than its predecessor, and as the older leaves fall off, the apical portion of each shoot is clothed with a tuft of leaves the size of which forms an indication of the stage to which the disease has progressed. Finally, to quote Mr. McCarthy's words, "the new shoots present the appearance of fine spikes, bearing four rows of fine bristles."

This forced growth, which I take to be the dominant character of the disease, is further indicated by the bursting out of old buds on diseased shoots below the diseased portion; by excessive branching; and by the occurrence of "phyllody" or the transformation of the normal petals, sepals, etc., into small foliage leaves, in the inflorescence. None of the last three symptoms are constant, but all are sufficiently common to be distinctly associated with the disease. Where the bursting out of old buds is well marked on a shoot far advanced in the disease, it can be clearly seen that the buds break out into spiked shoots at the same stage of the disease as that to which the apical growing portion has arrived. So that when the main shoot bears nothing but a tuft of fine bristles at its apex, the new lateral shoots, often formed a considerable distance lower down, come out also with tiny bristle-like leaves in place of the ordinary foliage. And this rule by which all new-formed shoots on a diseased branch show the same degree of spike, is general for the whole diseased area of the tree, or for the whole tree where the disease has from the first affected all parts. It can point to nothing else but to a profound disturbance in the nutrition of the tree.

Phyllody appears to occur only where the inflorescence is already partially formed before the first development of spike on the inflorescence-bearing branch. Branches already attacked never bear any inflorescence

at all. Phyllody is, as Mr. Barber points out, usually an evidence of increased nutrition or of the stimulation of a parasite. Since all the other evidence points to increased nutrition, and since, as will presently be seen, no parasite could be found, it is probable that the phyllody is to be taken as due merely to excessive nutrition in the early stages of the disease. The absence of flowers, which in Sandal, as in many other plants, normally appear at the termination of vegetative activity, is similarly an evidence of increased nutrition resulting in a prolongation of vegetative growth beyond the normal. The alternative explanation, that the prolongation of vegetative growth results from the failure from some other cause to form flowers, need not be taken into account, since there is abundant evidence from the internal examination of the tissues of an increased nutrition, and since this increased nutrition is quite sufficient by itself to account for the phenomenon in question. Later on, when the tree becomes exhausted from the continuous vegetative activity, flower production would involve too great a drain on its resources to be possible.

Thus the two salient and constant external features of the disease are an increased vegetative activity, and a failure to form flowers; both evidences of a forced and possibly abnormal nutrition.

Condition of the tissues.

4. A detailed microscopical examination was made of the tissues from leaf to root and checked by a series of preparations kindly lent to me by Mr. Barber. The first fact noted was the absence of any trace of parasitic action sufficient to account for the disease, in any part of the diseased trees. A few fungus-hyphæ were found on epidermis and cortex, a few bacteria in the tissues, and some probably saprophytic organisms on the roots; but these were similarly found in healthy trees, and were in any case totally inadequate to produce such marked symptoms of disease.

At first sight the tissues appeared normal, and nothing resembling a degenerative change was observed. Certain departures from the normal, however, occur, and must be carefully considered as they form the only clue to the

nature of the disease. The most prominent is that all the parenchymatous tissues of a diseased tree are loaded with starch, which is present in enormously greater quantities than in a healthy tree. With this great increase of starch certain structural alterations are noticeable. The leaf is thickened in substance while much diminished in surface area, this hypertrophy being due not so much to an increase in the number of layers of cells as to their elongation at right angles to the surface of the leaf. This is especially towards the upper surface of the leaf where the sub-epidermal cells are about twice as long as those of the healthy leaf; thus a well marked palisade tissue is formed, which is absent in the healthy leaf. All the cells of the internal tissue of the leaf, or mesophyllum, are loaded with starch; and as the enormous quantity of starch in the storage cells of the plant shows, the function of carbon assimilation is progressing with quite abnormal vigour. I think the cellular hypertrophy of the leaf is probably an effort to deal with this excessive starch-formation, and to compensate for the diminished surface area presented by the diseased leaves. That a compensatory effort is being made by the plant in this case is supported by an examination of the epidermis, which shows that the stomata, or openings by which air, bearing carbon-dioxide for the nutrition of the plant, enters, are very greatly increased in number in a given area as compared with a healthy leaf. It is probable that, at least in the early stages of the disease, the amount of carbon-dioxide, which enters the plant, is, in spite of the diminished leaf area, at least equal to that of the normal tree, and the hypertrophy of the leaf-cells, in view of their diminished number, may be an effort to deal with this. The only alteration in the internal structure of the stem is a somewhat diminished and irregular formation of vascular tissue in advanced cases, which is not visible in the early stages of the disease.

The roots are perfectly healthy, with the exception, noted by Mr. Barber, of the root-ends and "haustoria."

The chief internal evidences of the disease are then an excessive production of starch, together with certain structural alterations in the tissues.

5. It has recently been shown that a certain train of modifications in the structure of a plant occurs when the plant is forced to take in excessive quantities of carbon-dioxide by exposure to an atmosphere unduly charged with this gas. These are, shortly, as follows :—

Meaning of the modifications.

1. The elongation of the internodes is checked; but the period of growth, *i.e.*, of vegetative activity, is lengthened.

2. The growth in surface of the leaves is early arrested.

3. The absolute number of stomata in a given area of leaf surface is considerably increased, though the proportion of stomata to epidermal cells is about the same as in normal leaves, all the cells being diminished in size.

In other words, the number of stomata on the leaf is increased, as though to compensate for the diminution in size.

4. The structure of the leaves is not materially altered.

5. The xylem, or inner portion of the vascular ring, of the stem, is less perfectly developed.

6. Starch is accumulated in the leaves and parenchymatous tissues.

7. No alteration can be detected in the roots.

This group of modifications shows so striking a resemblance to those above described, as characterising Spike disease in sandal, that they are worthy of careful consideration.

The main features common to both are the forced carbon-assimilation resulting in an accumulation of starch in the plant; the increased production of leaves, shown in the shortening of the internodes; and the prolongation of vegetative activity. Since, in the experiments just mentioned, forced carbon-assimilation was the obvious result of the increased supply of carbon-dioxide, it is at least likely that the remaining train of

modifications resulted directly from this. Hence it is evidently possible that the whole of the alterations observed in Spike disease are directly due to intensified carbon-assimilation, or are the result of overloading the plant with starch. The only prominent modification present in spike, not observed in these experiments, is the leaf hypertrophy, and this may be due to some factor not present in the plants experimented with. It, therefore, appears to me probable that the intensified carbon-assimilation is the modification to which attention should be directed, and that most of the other alterations are consequences of this.

We have, unfortunately, as yet nothing to guide us as to the cause of the intensified carbon assimilation in spiked sandal. It would be absurd to suppose it due to unusual quantities of carbon-dioxide in the atmosphere. The effects of such a condition would have been rapidly visible on the human population of the country affected. The cause must, therefore, be sought in the plant itself. For some reason or other the tree, or some isolated branches of it, suddenly proceeds to manufacture starch out of all proportion to the demand for this food by the tissues. As a result of this, growth is forced, the tree gets no rest, and dies of exhaustion, the result of starch-poisoning.

Possible causes of intensified carbon-assimilation.

6. In the plant itself a disease of the stomata, or of the starch-forming cells, or the circulation of some substance in the sap, might each account for the forced production of starch. The stomata are certainly much altered, lying flush with the surface of the leaf, instead of forming a depression in the epidermis as in the healthy plant. But I can find apparent cause for this, and the condition is probably secondary to the leaf-hypertrophy. The starch-forming cells are apparently healthy. The existence of a poison in the sap can only be determined by a series of infection experiments carefully conducted over a number of years. I fail to see how the mere destruction of the root-ends could possibly result in an increased formation of starch, for that starch is formed in excessive quantity, and not merely stored up because

not consumed in normal amount as fast as it is formed, is evident from the fact that growth is actually increased, and that, therefore, more starch than usual must be actually consumed. But the destruction of rootlets may well be an early evidence of the action of some poison circulating in the plant. That this poison, if present, actually enters through the root-ends, we have nothing to show, since no organism has as yet been found in the roots that would be likely to be a source of disease. The fact that in addition to the free rootlets, the organs of attachment to other roots, or "haustoria", through which a portion of the food of the sandal tree is absorbed, are also dead in spiked trees, tells against a local disease of the rootlets alone. The existence of a poison circulating in the sap seems, therefore, to be the most probable explanation of the suddenly intensified starch manufacture.

Association with Lantana.

7. We come now to the association of the Lantana invasion of Coorg with the appearance of the disease, first called attention to by Mr. McCarthy. In a search for any recent change in the conditions of sandal-growing, this is the one striking new factor. It might be thought an easy matter to exonerate Lantana from any share in the disease. But this is not so easy as it looks. For several days I sought round Fraserpet to find a spiked tree isolated from Lantana, but without success. When we remember the great distances to which the roots of sandal extend, probably at least fifty yards, and the general nature of the Lantana invasion, this failure may be understood. Still the near future must settle this, for spike disease is progressive, and the area covered by Lantana restricted. If the disease continues to spread into Mysore, as it appears to be doing, and extends beyond the Lantana country, then it obviously cannot be traced to this source. If, on the other hand, spike disease remains confined to the Lantana country, and its originally rapid spread is checked, then there is grave reason to suspect the Lantana and a definite, though not very hopeful, objective to which to direct our preventive measures.

A definite communicable disease.

8. That the condition is a definite disease and communicable, the study of the plantations around Fraserpet, and in parti-

cular of the "River," plantation clearly shows. In this plantation a fire destroyed the outer fringe of sandal. Fire, as Mr. McCarthy mentions, is a predisposing cause to this, as to some other, diseases. The outer trees which had survived the fire took spike, while those inside remained healthy. I may mention in parenthesis that these outer trees grew out of Lantana, while those inside were isolated. But the disease from that time has slowly progressed in a centripetal direction, until now, after some years, the plantation is practically destroyed. The slow and steady nature of this progression seems to point to underground communication, and since Mr. Barber has shown that sandal roots form connections with other sandal roots, a channel through which the virus might pass from tree to tree is here evident. In opposition to this slow infection, probably occurring from tree to tree, there is the first invasion of the disease which was rapid. It is as if a first wave of the disease passed rapidly through the air, and that those trees which escaped this first attack were afterwards slowly killed out by underground spreading, a mode of extension which is always gradual. The whole country round Fraserpet shows evidences of this secondary and gradual spread in a centrifugal direction from trees which succumbed to the first attack.

Course of the disease.

9. It is probable that death follows the first appearance of the disease much more rapidly than was at first suspected. Thus a tree which was observed during Mr. Barber's visit to be showing the earliest signs of spike, was, at the time of my arrival at Fraserpet six weeks later, far developed in the disease. Instead of years, we must probably speak of months in estimating the rate of progress. No case of recovery has as yet been reported.

Treatment.

10. The all-important question of treatment is naturally a difficult one where the cause of disease is unknown. Still it is far from being insoluble. One of the most serious diseases with which American fruit-growers have to contend is that known as "Peach yellows". For more than twenty years this disease has ravaged the Eastern States, and its nature remains to this day as obscure as in the beginning. The best energies of the United States

Department of Agriculture have been directed towards ascertaining its origin, but without success. One after another all the more usual causes of disease, fungi, insects, bacteria, etc., have been excluded, yet there is full evidence of the infectious nature of the disease. And the treatment is on the whole fairly successful, so that the disease is under reasonable control. "Peach yellows" bears several remarkable resemblances to spike disease, and one of the explanations offered of it is the presence of an infectious fluid in the sap. The success in checking this disease holds out a fair hope for the eventual controlling of spike.

The first thing to be done is clearly to endeavour to confine the disease to the area at present infected. The not uncommon escape of isolated trees gives an indication which might usefully be followed up. A belt of country around the diseased districts ought, in my opinion, to be cleared entirely of sandal trees. This belt, judging from the known length to which roots extend, should be not less than 100 yards wide. The taking out of every tree in such a belt all round the infected area ought not to be very difficult when we take into account the scattered way in which sandal grows, a tree here and a tree there. The local forest officer will be the best judge of that, and I am in correspondence with him on the subject. It would seem to me that the Mysore Government should be asked to co-operate in the work, as it is certainly useless to endeavour to eradicate the disease in Coorg if, across the Cauvery in Mysore, spiked trees are allowed to remain to be possible sources of infection. Diseased trees are at present being removed in large quantities in Coorg for the yearly sales, and this practice might well be followed in Mysore, for the evidence of communication from tree to tree cannot now be ignored, although the fact is not yet scientifically proved. So far as microscopical examination can show, the disease causes no deterioration in the quality of the wood. The disease must soon lessen its intensity in districts such as the vicinity of Fraserpet, from the very fact that there will shortly be little sandal left for attack. To endeavour to eradicate all spiked trees in such acutely infected areas, impossible up to the present, may then become practi-

cable as more and more is cut down or destroyed by the disease, and the new generation may be preserved; for it is an important fact that young trees do not usually suffer. In freshly infected areas I would strongly advocate the total extirpation of a tree the moment it shows signs of spike, and the burning on the spot ofall the *debris* from rough-dressing the wood. In "Peach yellows" the living tissues have been proved to be highly infectious, and in its mode of spreading and many of its symptoms, this disease is closely allied. Hence the danger of disseminating infectious matter during the removal of the tree must be borne in mind.

Experimental work.

11. These recommendations, which are only too scanty, are all that I think it is justifiable to suggest in the absence of experimental work. I may add that excision of diseased branches in early stages does not seem to have any effect in checking the extension to other parts of the tree.

Further work must be guided entirely by the results of experiments, which I hope to be able to commence with Mr. McCarthy's aid immediately. These experiments cannot be carried through in a short time, but must extend over several seasons before any trustworthy results can be arrived at. One great difficulty in the way is that the work can only be carried on in already infected areas, since there would otherwise be a risk of spreading the disease to new districts. It will be hard to find suitable healthy trees for inoculation under such conditions that the danger of infection from outside is inconsiderable. The experiments will be directed chiefly to determine the mode of spread of the disease; its period of incubation; the nature of the virus; and the influence of the "nurse" plant, *i.e.*, the plant from whose roots the sandal draws a portion of its nourishment, on the development of the disease. Their results will be communicated at a subsequent date.

Summary.

12. It will be evident from what I have said above that I consider spike in sandal to be a nutritional disease, characterised by a forced carbon-assimilation and a consequent train of

modifications in the form of the tree. No parasite origin can be assigned. The cause of the forced carbon-assimilation is unknown, but is probably not local. It may be due to the circulation of a poison in the sap. The disease shows marked similarities to "Peach yellows," and, like it, there is reason to believe it is communicable. Treatment at present must be chiefly directed to confining the disease to its present limits. Experimental work is necessary before further recommendations can be given.

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Pilzkrankheiten in Indien im Jahre 1903.

Von E. J. Butler, Cryptogamic Botanist to the Government of India.
(Dehra Dun U. P.)

Im Folgenden gebe ich eine Übersicht über die bemerkenswertesten Pflanzenkrankheiten, die dem Laboratorium des Cryptogamischen Botanikers der ostindischen Regierung während des Jahres 1903 zugegangen sind, oder die ich auf meinen Reisen in demselben Jahre beobachtet habe.

I. Getreidearten und Futtergewächse. Rost hat sich im Jahre 1903 nicht viel gezeigt. *Puccinia glumarum* E. u. H. fand sich am häufigsten auf Weizen und Gerste und wurde auch auf *Phalaris minor* bemerkt. Die Teleutosporen sind sehr selten mit Paraphysen versehen, was von Barclay und andern in Indien und auch, minder häufig, von Speschnew im Kaukasus bemerkt wurde. (Zeitschrift für Pflanzenkr. IX. S. 357.) — *P. graminis* Pers. trat auf Weizen und Gerste auf, hat aber weniger Schaden als *P. glumarum* verursacht, wenigstens in den Gegenden, wo die Fortschritte der Krankheit systematisch beobachtet wurden. — *P. triticina* E. trat sehr häufig auf Weizen auf. Sie kommt oft nur in der Uredoform vor. Diese Pilze erscheinen über ganz Indien von dem Himalaya bis nach Madras hin verbreitet, und sind die schädlichsten von allen für die Getreidearten. Zwischenwirte, die die Aecidienformen tragen, sind nicht gefunden worden, ausgenommen in dem Himalayagebirge, und den nächstliegenden Berberitzenstrauch trifft man oft mehrere hundert Meilen von den Orten in den Ebenen, wo *P. graminis* häufig vorkommt. Sehr bemerkenswert ist die Tatsache, dass man in Indien gar keinen Rost auf dem Hafer gefunden hat, obschon, während der letzten zwei Jahre, manche Versuche, denselben zu finden, gemacht worden sind. — *Puccinia purpurea* Ck. (*P. Pennisieti* Barc.) tritt auf *Andropogon Sorghum* auf. — *Uromyces striatus* Schroet. wurde auf *Medicago sativa*, die vom Pandschab kam, gefunden. Mehrere Futtergräser wurden beobachtet, die von Rost angegriffen waren: *Puccinia Cynodontis* Des. auf *Cynodon Dactylon*, *P. Duthiae* Ell. u. Tr. auf *Andropogon pertusus* und *P. Paspali* Tr. u. Ear. auf *Paspalum sanguinale* traten häufig in Dehra Dun auf. — Brandpilze sind sehr verbreitet. *Ustilago Tritici* (Pers.) Jens. wurde auf Weizen gefunden; *U. Hordei* (Pers.) Kell. u. Swing. auf Gerste und *U. Avenae* (Pers.) Jen. auf Hafer. Dieser letztere Pilz richtet grossen Schaden im Norden von Ostindien an. — *Andropogon Sorghum* („Jowar"), das eine der bedeutendsten Getreidearten Ostindiens ist, wird viel von *Ustilago Sorghi* (Lk.) Pass. und

von *U. Reiliana* Kühn beschädigt. Ersterer kommt am häufigsten vor und ist von der schädlichsten Wirkung. Behandlungen mit einer halbprozentigen Lösung von Kupfervitriol haben sehr gute Erfolge und werden von den Bauern in einigen Orten ausgeführt. — *U. Cynodontis* Henn. ist einer der am meisten verbreiteten Brandpilze Ostindiens und wird in allen Landesteilen auf *Cynodon Dactylon* gefunden. *U. furcata* Pat. u. Har. wurde auf *Andropogon pertusus* und *U. Andropogonis annulati* Bref. auf *Andropogon annulatus* gefunden. — *Erysiphe graminis* Lév. tritt häufig in Dehra Dun auf Weizen und Gerste auf. — *Helminthosporium Avenae* Br. u. Cav. zeigt sich am Hafer und *H. graminis* Rabh. an Gerste. — *Dimerosporium erysiphoides* E. u. E. wurde auf *Paspalum scrobiculatum* gefunden. — *Phoma glumarum* Ell. u. Tr. tritt weitverbreitet in Bengalen und Bombay auf Reis auf und scheint grossen Schaden anzurichten. — *Colletotrichum Lineola* Corda kommt sehr häufig vor und verursacht rote Flecke auf den Blättern von *Andropogon Sorghum*.

II. Hülsenfrüchte, Kartoffeln, Tomaten u. s. w. Ein mit *Fusarium vasinfectum* Atk. (*Neocosmospora vasinfecta* Sm.) verwandtes Fusarium verursacht jedes Jahr sehr grosse Verluste durch eine Welkkrankheit, die es auf *Cajanus indicus*, einer der Hülsenfrüchte, die am meisten in Indien kultiviert werden, hervorruft. — *Phytophthora infestans* de Bary ist in manchen Gegenden Indiens auf Kartoffeln epidemisch, und hat sich neuerdings in den Ebenen von Bengalen gezeigt, wo es festen Fuss gefasst hat, ungeachtet der sehr hohen Temperatur, welcher das schlafende Mycelium während der Sommerhitze zweifellos ausgesetzt ist. — Schwarzbeinigkeit verursacht auch viel Schaden in vielen Orten. — „Early-blight", durch *Alternaria Solani* Sor. verursacht, kam an einigen Orten vor. — Bei einer Tomatenkrankheit wurde *Cladosporium fulvum* Ck. gefunden; man hat aber nicht bewiesen, dass der Pilz die Ursache dieser Krankheit sei. — In Bengalen wurde *Solanum Melongena* („Brinjal") von einer Art *Colletotrichum* befallen, die eine schädliche Fäule der Früchte verursacht.

III. Zuckerrohr. In erster Linie kommt die durch *Colletotrichum falcatum* Went. veranlasste „Red-rot" in Betracht. Diese Krankheit hat ungeheuren Schaden in Madras verursacht, und man berichtet über das Auftreten derselben in anderen Teilen Ostindiens. Genügende Beweise sind zur Hand, dass diese Krankheit meistens dadurch verbreitet wird, dass man infizierte Stecklinge zur Vermehrung benutzt. — *Ustilago Sacchari* Rabh. wird sporadisch gefunden und greift nur bestimmte Arten des Zuckerrohrs an. Das sind gewöhnlich diejenigen, welche mit den wilden Saccharumarten am nächsten verwandt sind, und welche die in manchen Sorten verlorengegangene Blütenentwicklung beibehalten haben. — *Cercospora longipes*

Butl. verursacht „Brown-spot“, eine Blätterkrankheit, die in Bengalen sehr verbreitet ist. — *Leptosphaeria Sacchari* Br. u. Ha. tritt häufig auf dem Zuckerrohr des Bourbon Typus auf. — *Cercospora vaginae* Kr. und eine Sclerotienkrankheit, welche scheinbar mit der Schwarzfäule von Java identisch ist, wurden in Madras gefunden. — *Diplodia cacaoicola* Henn. kommt am meisten als Saprophyt vor. — *Sphaeronaema adiposum* Butl. verursacht eine Schwarzfäule auf Stecklingen; es ist aber noch unbekannt, wie gross der Schaden wirklich ist, den es anrichtet. — *Trichosphaeria Sacchari* Mass. ist in Indien sehr selten und *Thielaviopsis ethacethicus* Went. ist noch nicht dort gefunden worden.

IV. Tee- und Kaffeepflanzen. Die Alge *Cephaleuros virescens* K. ist die gefährlichste der durch cryptogamische Parasiten verursachten Krankheiten des Teestrauches in Indien. Zwei Formen kommen vor. Die eine, welche wenig Schaden anrichtet, tritt auf den Blättern auf, und ist immer in ihren letzten Entwicklungsstufen mit einem Pilz associiert, um ein Lichen zu formen. Die andere kommt auf den Zweigen ohne Lichenformation vor, und tötet den Zweig, indem sie die Rinde angreift. Experimente, die gegenwärtig gemacht werden, scheinen Beweise zu liefern, dass Bordeauxbrühe als Zerstörungsmittel dagegen wirksam ist. — *Pestalozzia Guepini* Des. verursacht „grey-blight“, die häufig vorkommt und bedeutenden Schaden anrichtet. — *Colletotrichum Camelliae* Mass. wurde seltener gesehen. — *Cercospora Theae* Br. u. Ha. verursacht die „shot-hole“-Krankheit, die von geringer Bedeutung ist. — *Stilbum nanum* Mass. („Thread-Blight“), dessen weisses, fadenähnliches Mycelium auf manchen wilden Pflanzen in den Wäldern, wie auch auf der Teepflanze gefunden wird, hat viel Schaden an manchen Orten verursacht. — Auf einzelnen Gütern wurden ganze Strecken, die mit Teesträuchern bedeckt waren, zerstört durch die Angriffe einer *Rosellinia* (vielleicht *R. radiciperda* Mass.). Diese Krankheit wurde dadurch verursacht, dass man die verfaulenden Stümpfe der gefällten Bäume im Boden vermodern liess. — Eine andere Wurzelkrankheit wird durch eine Art *Diplodia* hervorgebracht, und tritt meistens auf Sämlingen auf. — *Heilemia vastatrix* ist noch immer der schädlichste Feind der Kaffeekultur in Mysore. — In den Gegenden, wo es häufig regnet, ruft die durch *Pellicularia Koleroga* Ck. verursachte „Black-rot“-Krankheit fast ebensoviel Schaden hervor. — Zwei bestimmte Formen Wurzelkrankheiten scheinen in Mysore vorhanden zu sein. Die eine gleicht der obengenannten, die auf der Teepflanze auftritt, und wird durch eine noch nicht identifizierte *Rosellinia* verursacht. Die andere wird auch durch einen die Wurzeln angreifenden Pilz veranlasst; man hat aber die Natur desselben noch nicht bestimmt.

V. Palmen. *Graphiola Phoenicis* (Fr.) Poit. wurde auf *Phoenix dactylifera* und *Ph. silvestris*, *Exosporium palmivorum* Sacc. auf *Phoenix humilis* gefunden, sowie eine *Phytophthora*, die eine wichtige Krankheit von *Areca Catechu* verursacht. Die letztere kommt in Teilen von Mysore und wahrscheinlich in anderen Gegenden vor. Die Früchte werden zuerst angegriffen, werden schwarz und fallen herunter. Dann kriecht der Pilz zurück über den Fruchtstengel bis zur Blätterkrone, wo er eine weiche Fäulnis verursacht. Endlich fällt die ganze Krone ab, und der tote Stamm steht ganz nackt.

VI. Holzgewächse. Der Sandelholzbaum (*Santalum album*) wird in vielen Gegenden Indiens durch eine geheimnisvolle Krankheit gänzlich ausgerottet. Man nennt diese Krankheit „Spike disease" wegen der Änderung, die verursacht, dass die jungen Sprossen zu ährenartigen Gebilden werden. Die Krankheit verbreitet sich immer weiter und ist immer verderblich; die Ursache derselben bleibt unbekannt. Sie hat eine gewisse Ähnlichkeit mit dem „Peach-yellows" der Vereinigten Staaten. — Man fand in dem Himalayagebirge *Cedrus Deodara*, die sehr von *Polyporus annosus* Fr. angegriffen war. Der Pilz verbreitet sich mittels hoch entwickelter Rhizomorphen. — *Acacia arabica* stirbt seit einiger Zeit in Berar durch die Angriffe eines Pilzes, den man endlich als *Fomes Passianus* erkannt hat. Er war früher nicht als Parasit bekannt. — Der Pilz *Trichosporium aterrimum* Mass. (nicht (Corda) Sacc.) wurde auf *Casuarina equisetifolia* gefunden. Der Pilz reicht bis zur Cambiumschicht und scheint den Bäumen viel zu schaden. — *Peridermium Piceae* Barc. und *Barclayella deformans* (Barc.) Diet. wurden auf *Picea Morinda*, *Peridermium brevius* Barc. auf *Pinus longifolia* und *P. Ephedrae* Ck. auf *Ephedra vulgaris*, sämtlich im Himalaya beobachtet. — *Uredo Tectonae* Rae hat man in Mysore auf den Blättern von *Tectona grandis* entdeckt.

VII. Verschiedenes. *Uncinula necator* Sch. (Oidiumform) und *Sphaceloma ampelinum* De Bary wurden alle beide in der Bombay Presidency gefunden, wo sie Reben angriffen. — *Botrytis vulgaris* Fr. trat auf *Primula*-Sorten in Dehra Dun auf. — *Septogloeum Arachidis* Rac. verursachte sehr grossen Schaden durch seine Angriffe auf *Arachis hypogaea*. — Man beobachtete, dass *Agave rigida* var. *Sisalana* an einer mit *Colletotrichum Agaves* Cav. associierten Krankheit litt; es hat sich aber nicht erwiesen, dass der Pilz die Ursache der Krankheit sei. — *Ricinus communis* wurde von *Melampsorella Ricini* (Biv. Bern.) Pass. in der Uredoform nur in Bombay angegriffen. — *Linum usitatissimum* ist in manchen Jahren viel durch *Melampsora Lini* beschädigt Dieser ist ein Pilz, der in erster Reihe unter den verderblichen Pilzen Indiens zu nennen ist. — *Macrophoma Musae* (Ck.) Ber. u. Vog. wurde auf *Musa sapientum* in Dehra Dun beobachtet.

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THE BEARING OF MENDELISM ON THE SUSCEPTIBILITY OF WHEAT TO RUST.

By E. J. BUTLER, M.B., F.L.S.,

Cryptogamic Botanist to the Government of India.

In Mr Biffen's paper on "Mendel's Laws of Inheritance and Wheat Breeding" in the first number of this *Journal* reference is made on page 40 to the characters of immunity and susceptibility to the attacks of yellow rust. Mr Biffen's experiments confirm the conclusions of other observers, such as Farrer in Australia, that resistance and susceptibility to rust are inherited characters, and he shows that they follow the Mendelian laws. As the question is of enormous practical importance in the wheat growing countries this general statement requires to be made more precise. It holds for a given rust in a particular locality; it may or may not hold where the wheat is exposed to the attacks of a second species of rust or when it is transferred to another locality. Thus experience in India so far seems to show that resistance to yellow rust, *Puccinia glumarum*, does not imply resistance to orange rust, *P. triticina*. And it is certain that the characters alter with change of locality. Several of Farrer's hybrids resistant to Australian rusts have proved susceptible to the same rusts in India. On the other hand *Kathia* wheat, which is particularly liable to the attacks of all three Indian wheat rusts, has been recommended by Carleton for extended trial in the United States, having shown a promising degree of resistance to yellow rust there. A still more striking case is that of spelt wheat, which has proved very resistant in some parts of India and not in others. Therefore in the breeding of rust-resistant wheats the results of work in one locality should be accepted with caution in others as long as we do not know on what immunity depends. In spite of this it is impossible to exaggerate the practical value, for countries like India, where the extension of wheat cultivation is largely bound up

with the production of wheats possessing certain definite characters, such as resistance to rust, drought, &c., of the work already done in defining the lines on which wheat breeding must proceed in the future.

In the same section of his paper Mr Biffen concludes that his results are opposed to the assumption of a latent germ in the wheat grain, through which the disease is transmitted from season to season. For he found that the progeny of a cross were equally susceptible whether the male or female parent was the susceptible one, although the latent germ must necessarily arise from the female only. Though Eriksson's "mycoplasm" hypothesis requires establishment on a more solid basis than has been the case so far, still it is difficult to see how the results mentioned vitiate it. Were it the case that immunity depends on the absence of the latent germ from the grain, then Mr Biffen would probably be right. But there is an immunity dependent on the behaviour of the tissues of the leaf to infection by spores which should not be lost sight of. Mr Massee[1] and Mr Salmon[2] have shown how the resistance of a leaf may be overcome by appropriate chemical or physical treatment, and Professor Marshall Ward[3] that resistance to yellow rust is due to the reaction between the uredospores and the leaf-cells, and has nothing to do with the character of the grain. That susceptibility to rust means this liability to uredospore infection, and not a large proportion of germ-bearing grains is shown by the following experiment. A tent of thin cloth, more or less impervious to air-borne spores, 19 × 10 ft., was erected on one of my wheat plots at Dehra Dun on December 18th, 1904. Yellow rust was first observed in the field on January 1st, 1905. The tent was opened on February 11th, by which time a good deal of rust had developed on the surrounding wheat. The rusted leaves within the tent were counted, and 160 leaves bearing uredo sori collected within 1½ feet of the margin while the remainder of the area enclosed by the tent gave 24 only. So that in the marginal 78 square feet 160 leaves bore rust, while the central 112 square feet had only 24. Were the rusting of this wheat—a moderately susceptible one—due to a large number of latent germs in the grain, there is no explanation of this difference. As a matter of fact it was clear that the rusting of the margin was due to the entrance of aphides and other insects, carrying uredospores, at the ground level where the tent cloth was fastened down by stones only, and considerable numbers of these

[1] *Phil. Trans.* Vol. CXCVII. 1904.
[2] *Annals of Botany*, Vol. XIX. No. LXXIII. p. 125, 1905.
[3] *Ibid.* p. 39.

insects were found near the edge. They were fewer towards the centre, and secondary infection of the central part from the rust near the margin had not occurred to any great extent both from the shortness of time which had elapsed before the tent was opened and from the stillness of the air inside. We are therefore, I think, justified in concluding that susceptibility to rust depends on the liability of the leaves to uredospore attack, and that the latent germ, if it exist at all, can only do so in a comparatively small proportion of grains. No wheat is as yet known on which rust may not sometimes appear, so that immune sorts may bear the latent germ for all we know as often as the susceptible. And it also follows that experiments to test the existence of the germ by growing wheat in spore-tight cases, where only a few plants can be grown, are not likely to give positive results except accidentally, whether the hypothesis be true or not. Finally, if the presence or absence of the germ be independent of the susceptibility or immunity of the wheat to rust, then the behaviour of wheat in regard to Mendel's laws can have no bearing on the "mycoplasm" hypothesis.